Tracking System Performance Tests in the MDS Era

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This article describes tracking system performance tests as developed to support DSN Mark III Data Subsystem implementation project and prepass readiness tests. Tracking SPT software and test configurations are described. Future test software requirements and areas of current development are noted.

I. Introduction

The DSN Tracking System (DTK) is currently being updated to the Mark III-77 configuration (Refs. 1 and 2). The first phase of this update is the DSN Mark III Data Subsystem (MDS) Implementation Project, which replaces at each Deep Space Station (DSS) the Tracking Data Handling (TDH) Subsystem and those functions of the Digital Instrumentation Subsystem (DIS) which formerly collected and formatted radio metric data into a form suitable for transmission by the Ground Communications Facility (GCF) with the Metric Data Assembly (MDA), a MODCOMP II minicomputer. In the new configuration, all tracking system data is collected and formatted by the MDA. Data that is to be transmitted via the GCF to the user is formatted into a high-speed data (HSD) block and "embedded" into a subsystem block (SSB), then transmitted by the MDA to the Communications Monitor and Formatter (CMF) via the DIS Monitor and Interface Assembly (DMI) star switch controllers (SSC). The CMF strips the HSD block from the SSB and inserts the proper error polynominal and then transmits the data. Data that is to be displayed by the DSS Monitor and Control Subsystem (DMC) is formatted into SSBs and transmitted to the DMC via the DMI.

Prior to the MDS implementation, Tracking System Performance Test (SPT) software was resident in the DIS and collected radio metric data for analysis purposes at the DIS-TDH interface in real-time. Obviously, a new tracking SPT test program would be necessary to support SPTs after MDS implementation, to support future mission configuration tests (MCT) and for operational support of prepass readiness tests. This article describes the system test design and rationale chosen for implementation and the inevitable compromises imposed by schedule constraints and resources.

II. Test Design

The functional requirements for the tracking system SPT program are listed in Table 1. The program design was to include all of the listed functions, with implementation carried out in a phased manner as necessary to deal with the realities of the hardware implementation schedule and the planned several different phases of the MDA operational software implementation. The requirements are separated into two groups: those functions that had to be available immediately upon MDS implementation and those that would be necessary to meet future DTK capabilities, as well as MCT and PRT requirements. In addition, the functional requirements are listed in order of priority within the two groups.

Table 2 lists those capabilities and features the new tracking system SPT software design would have to include in order to satisfy these requirements. All of these desired features were incorporated into the new test program, but due to the necessity of meeting the operational schedule of the MDS project, some compromises were necessary.

The first feature dictated that the test software would reside in the spare CMF (see Fig. 1), hereafter referred to as the System Performance Test Assembly (SPTA), as this was the only logical location from which to monitor DSS outgoing data. HSD output of the operational CMF is looped back via GCF data sets as input to the SPTA. DSS system performance is monitored at the DSS output port and data analysis is a true reflection of DSS system performance.

Reduction of necessary test time (Feature 2) was considered to be of only slightly less importance than Feature 1, but implementation was considerably more involved. As the Deep Space Stations have become more and more complex to meet the requirements of the ever-increasing sophistication of new projects, system test requirements have also become more complex and stringent. Sophisticated and complex systems require sophisticated and complex testing, and this obviously requires more time to accomplish. Therefore, in order to reduce system test impact on tracking time, it was necessary to design test software that would allow as many different tests to be run simultaneously as possible.

Computerized semiautomatic test procedures and centralized operator control of both the test software and operational software were a second facet of this effort to reduce test time. This entailed designing the test program so that it could read the test procedure from a disc file and provide the test conductors with necessary prompting for equipment setup. This technique eliminates the need for the majority of operator type-ins, which reduces test setup time considerably. Manual testing capability with centralized operator control input was retained to allow special test configurations and troubleshooting to be performed with the test software.

The third goal was to provide certain new system test capabilities that were not available in the old test software. This was necessary to meet new system capabilities introduced with the MDS implementation and to correct some deficiencies in the old test program. These new capabilities include a predict system test, a HSD/SSB data dump and monitoring capability, a Block IV receiver frequency ramp test and a Meteorological Monitoring Assembly (MMA) test.

As a fourth goal it was desired to expand the doppler system noise model so that it predicted valid results at loop SNRs of less than 10 dB. In addition, the range noise model was modified to reflect the DSS stand-alone test configuration.

III. Implementation Status

Figure 2 shows the data flow path for the Tracking System Performance Test as it has been developed to support MDS implementation SPTs at DSS 14. It in effect represents a snapshot of functional test capabilities presently (June 1977) available in the test program. Once all of the operational and test software has been loaded and initialized and the necessary hardware configuration completed, then all test functions can be controlled from the DST. Test directives and/or operational directives are routed from the DST to the host computer (shown in the CMF in Fig. 2), which in turn routes it to the proper subsystem computer via the SSC. Status messages, acknowledgments and alarms are routed along the same path back to the DST for display.

A typical test mode would be for the DTK to generate radio metric SSBs from data received from, say, the PRA or the doppler system. These SSBs consist of "embedded" HSD blocks with a proper SSB header added. They are transmitted via the SSC to the CMF, which strips the SSB header and adds an error polynominal to the HSD block. The CMF sends the HSD to the HSD communications output buffer, where it is normally then transmitted to the project user; however, for the purposes of system testing the data is now looped back into the incoming HSD communications buffer, which routes it to the SPTA where it is analyzed.

At the SPTA the Test Executive Program is the resident communications handler for all SPT programs. It accepts directives that activate the proper SPT task. In this case it is the tracking test program. It can accept HSD or SSBs via the SSC; thus SPTs can be run in a "short loop" mode if necessary, obviating the need for the operational CMF to run a tracking test. The test executive routes the requested HSD/SSB data to the tracking test program, which analyzes the data and generates a test report which is output at either the printer/plotter or the local terminet.

The tracking test program validates the HSD headers as the data is received and generates alarm messages if something is amiss. The doppler and ranging analysis programs calculate theoretical noise values based on known or measured signal-to-noise ratios and compare these values to the measured noise. System specifications are used to determine "test passed" or "test failed" criteria. Any number of tests may be run simultaneously; for instance, at a 64-m DSS an S/X-band ranging performance test and S/X-band doppler performance can be run concurrently, resulting in an approximate 75% saving of test time, a matter of great importance for Prepass Readiness Tests. In addition, the tracking test program can generate and transmit test predict HSD blocks for testing the predict data handling capability.

IV. The Future

Although the MDS Implementation Project SPT support requirements have been met, much work remains to be done. The RF and antenna test functions were postponed because those systems could be supported using old test software. However, as these systems are automated and brought under software control, it will become more desirable to automate these tests, and preliminary work has begun in this area. Completely automated countdown procedures and tests are other capabilities currently being developed. Also, major modifications of the SPT software will be necessary in order to meet the new tracking HSD interface (TRK 2-14) to be introduced into the DSN in February 1978.

References

1. "Deep Space Network General Requirements and Plans," 820-20, Jet Propulsion Laboratory, Pasadena, Calif. (an internal document).
2. "Deep Space Station Subsystem Requirements – Tracking Subsystem 1974-1978," 824-2, Jet Propulsion Laboratory, Pasadena, Calif. (an internal document).

Table 1. Tracking SPT program functional requirements

Immediate requirements
Receive/verify DTK HSD/SSB blocks
Dump DTK HSD/SSB blocks
Evaluate doppler system performance
Evaluate ranging system performance
Display tracking system test results
Generate and transmit test predicts
Validate tracking ODR/TODR data
Maintain test log
Future requirements
Send control and configuration Msg's to DTK
Evaluate RF system performance
Calibrate RF system characteristics
Evaluate antenna system performance
Calibrate antenna characteristics
Generate simulated TRK system/data
Meet TRK 2-14 HSD interface

Table 2. New test program design features vs old program capabilities

New program design features	Old program comparable features
True system test that would analyze data as it left the station as HSD	Actually was a subsystem test that looked at the data at the TDH/DIS interface
Reduce test time by	None
(a) Simultaneous testing	
(b) Computerized procedures	
Provide new test capability for	None
(a) Predict system test	
(b) HSD/SSB data dumps and monitoring	
(c) POCA ramp test	
(d) MMA test	
Improved theoretical noise models for doppler and ranging	Modeled Block III receivers only. Doppler noise model valid for signal margin $\geqslant 10$ dB only. Range noise model incorrect for DSS stand alone testing

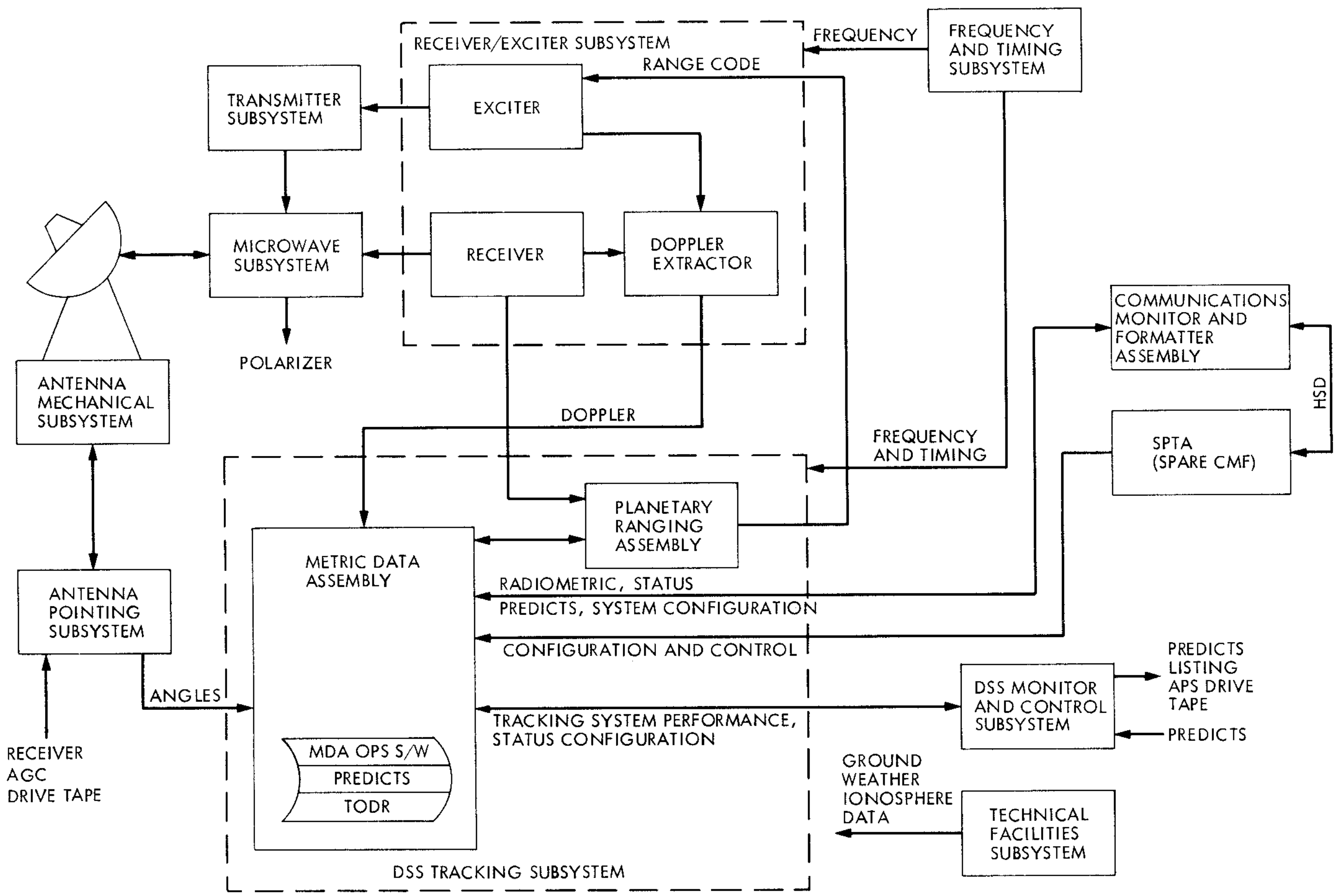

Fig. 1. Block diagram of the DSS tracking system configured for SPTS

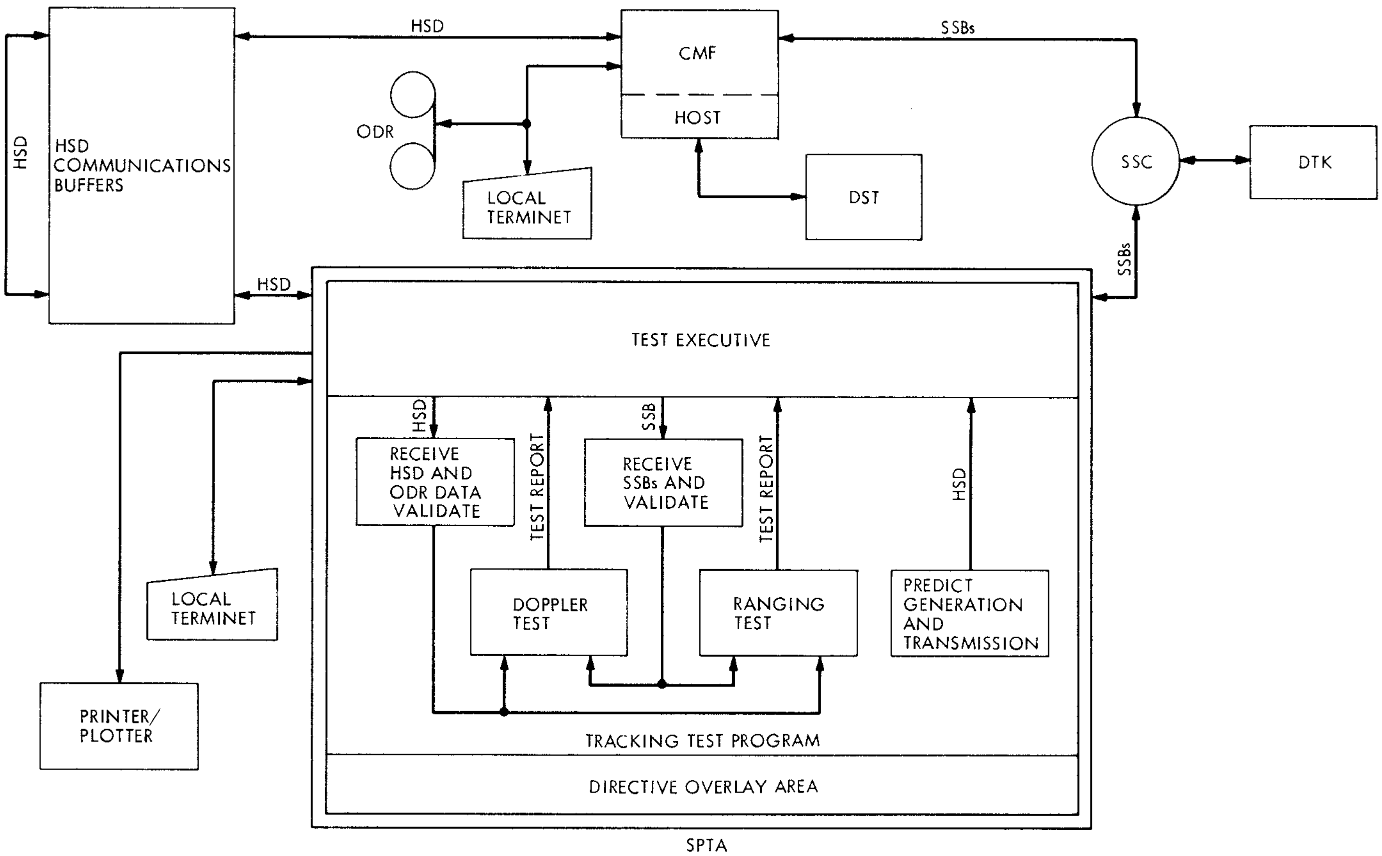

Fig. 2. Tracking system performance test data flow